

**Amendments to the Specification:**

I. Please replace the paragraph [0001] with the following amended paragraph:

[0001] This application is related to claims priority to and benefit of USSN 60/549,172, filed on March 2, 2004, and USSN 60/501,158, filed on September 8, 2003, both of which are incorporated herein by reference in their entirety for all purposes.

II. Please replace the paragraph [0014] with the following amended paragraph:

[0014] Thus, in one embodiment this invention provides a composition comprising a plurality of carbon fibers bearing nanoparticles (*e.g.*, nanotubes, nanofibers, nanohorns, nanopowders, nanospheres, quantum dots, *etc.*). The plurality of carbon fibers can comprise a porous electrode and/or a carbon paper. In certain embodiments, the nanoparticles comprise carbon nanotubes and the nanotubes are seeded with one or more nanotube growth catalysts selected from the group consisting of  $\text{Co}_{1-x}\text{Mo}_x$  where  $0 \leq x \leq 0.3$ ,  $\text{Co}_{1-x-y}\text{Ni}_x\text{Mo}_y$  where  $0.1 \leq x \leq 0.7$  and  $0 \leq y \leq 0.3$ ,  $\text{Co}_{1-x-y-z}\text{Ni}_x\text{V}_y\text{Cr}_z$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ ,  $0 \leq z \leq 0.2$ ,  $\text{Ni}_{1-x-y}\text{Mo}_x\text{Al}_y$  where  $0 \leq x \leq 0.2$  and  $0 \leq y \leq 0.2$ , and  $\text{Co}_{1-x-y}\text{Ni}_x\text{Al}_y$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ . Particularly preferred nanotube growth catalysts include, but are not limited to, and  $\text{Co}_{0.88}\text{Mo}_{0.12}$ ,  $\text{Co}_{0.8}\text{Mo}_{0.2}$ ,  $\text{Co}_{0.22}\text{Ni}_{0.56}\text{Mo}_{0.22}$ ,  $\text{Co}_{0.22}\text{Ni}_{0.56}\text{Mo}_{0.22}$ ,  $\text{Co}_{0.57}\text{Ni}_{0.21}\text{V}_{0.11}\text{Cr}_{0.11}$ ,  $\text{Co}_{0.57}\text{Ni}_{0.21}\text{V}_{0.11}\text{Cr}_{0.11}$ ,  $\text{Ni}_{0.8}\text{Mo}_{0.1}\text{Al}_{0.1}$ ,  $\text{Ni}_{0.8}\text{Mo}_{0.1}\text{Al}_{0.1}$ , and  $\text{Co}_{0.64}\text{Ni}_{0.24}\text{Al}_{0.12}$ ,  $\text{Co}_{0.64}\text{Ni}_{0.24}\text{Al}_{0.12}$ . In various embodiments, the nanoparticles are nanotubes having a length less than 50  $\mu\text{m}$  and/or a width/diameter less than about 100 nm or less than about 50 nm. The nanoparticles are typically coated with a substantially continuous thin film, preferably a catalytically active thin film, *e.g.*, a film comprising platinum or a platinum alloy. The thin film can partially or completely cover the nanoparticles and, in certain embodiments, ranges in thickness from about 1 to about 1000 angstroms, more typically from about 5 to about 100 or 500 angstroms.

III. Please replace the paragraph [0016] with the following amended paragraph:

[0016] Also provided is a fuel cell catalyst comprising a plurality of nanoparticles where the nanoparticles are coated with a substantially continuous catalytically active thin film, *e.g.*, a thin film comprising platinum or a platinum alloy. In certain embodiments, the nanoparticles are nanotubes. The nanotubes can be seeded with one or more nanotube

growth catalysts selected from the group consisting of  $\text{Co}_{1-x}\text{Mo}_x$  where  $0 \leq x \leq 0.3$ ,  $\text{Co}_{1-x-y}\text{Ni}_x\text{Mo}_y$  where  $0.1 \leq x \leq 0.7$  and  $0 \leq y \leq 0.3$ ,  $\text{Co}_{1-x-y-z}\text{Ni}_x\text{V}_y\text{Cr}_z$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ ,  $0 \leq z \leq 0.2$ ,  $\text{Ni}_{1-x-y}\text{Mo}_x\text{Al}_y$  where  $0 \leq x \leq 0.2$  and  $0 \leq y \leq 0.2$ , and  $\text{Co}_{1-x-y}\text{Ni}_x\text{Al}_y$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ . Particularly preferred nanotube growth catalysts include, but are not limited to  $\text{Co}_{0.88}\text{Mo}_{0.12}$ ,  $\text{Co}_{0.88}\text{Mo}_{0.12}$ ,  $\text{Co}_{0.22}\text{Ni}_{0.56}\text{Mo}_{0.22}$ ,  $\text{Co}_{0.57}\text{Ni}_{0.21}\text{V}_{0.11}\text{Cr}_{0.11}$ ,  $\text{Co}_{0.57}\text{Ni}_{0.21}\text{V}_{0.11}\text{Cr}_{0.11}$ ,  $\text{Ni}_{0.8}\text{Mo}_{0.1}\text{Al}_{0.1}$ ,  $\text{Ni}_{0.8}\text{Mo}_{0.1}\text{Al}_{0.1}$ , and  $\text{Co}_{0.64}\text{Ni}_{0.24}\text{Al}_{0.12}$ . In various embodiments, the nanotubes have a length less than  $50 \mu\text{m}$  and/or a width/diameter less than about 100 nm or less than about 50 nm. The thin film can partially or completely cover the nanoparticles and, in certain embodiments, ranges in thickness from about 1 to about 1000 angstroms, more typically from about 5 to about 100 or 500 angstroms.

IV. Please replace the paragraph [0017] with the following amended paragraph:

**[0017]** In certain embodiments, the thin film comprises an alloy comprising platinum (Pt), vanadium (V), and one or more metals selected from the group consisting of Co, Ni, Mo, Ta, W, and Zr, more typically selected from the group consisting of Co, and Ni. In certain embodiments, platinum comprises up to about 12%, 25%, or 50% (mole ratio or atomic percentage) of the alloy. In certain embodiments, the alloy contains platinum, vanadium, nickel, and copper. In certain embodiments, the thin film comprises an alloy having the formula:  $\text{Pt}_x\text{V}_y\text{Co}_z\text{Ni}_w$ , where  $x$  is greater than 0.06 and less than 1;  $y$ ,  $z$ , and  $w$  are independently greater than zero and less than 1; and  $x + y + z + w = 1$ . In certain embodiments,  $x$  is 0.12. In certain embodiments,  $x$  is 0.12,  $y$  is 0.07,  $z$  is 0.56, and  $w$  is 0.25. In certain embodiments, the nanoparticles are attached, or incorporated into, a substrate (e.g., a porous carbon substrate, a polymer substrate, carbon paper, *etc.*). The nanoparticles can be electrically coupled to an electrode. In certain embodiments, the nanoparticles are selected from the group consisting of nanotubes, nanofibers, nanohorns, nanopowders, nanospheres, and quantum dots. In certain embodiments, the nanoparticles are carbon nanotubes seeded with one or more catalysts selected from the group consisting of  $\text{Co}_{1-x}\text{Mo}_x$  where  $0 \leq x \leq 0.3$ ,  $\text{Co}_{1-x-y}\text{Ni}_x\text{Mo}_y$  where  $0.1 \leq x \leq 0.7$  and  $0 \leq y \leq 0.3$ ,  $\text{Co}_{1-x-y-z}\text{Ni}_x\text{V}_y\text{Cr}_z$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ ,  $0 \leq z \leq 0.2$ ,  $\text{Ni}_{1-x-y}\text{Mo}_x\text{Al}_y$  where  $0 \leq x \leq 0.2$  and  $0 \leq y \leq 0.2$ , and  $\text{Co}_{1-x-y}\text{Ni}_x\text{Al}_y$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ . In certain embodiments, the nanoparticles are carbon nanotubes seeded with one or

more catalysts selected from the group consisting of  $\text{Co}_{0.88}\text{Mo}_{0.12}\text{Ce}_{0.8}\text{Me}_{1.2}$ ,  $\text{Co}_{0.22}\text{Ni}_{0.56}\text{Mo}_{0.22}\text{Ce}_{2.2}\text{Ni}_{5.6}\text{Me}_{2.2}$ ,  $\text{Co}_{0.57}\text{Ni}_{0.21}\text{V}_{0.11}\text{Cr}_{0.11}\text{Ce}_{5.7}\text{Ni}_{2.1}\text{V}_{1.1}\text{Cr}_{1.1}$ ,  $\text{Ni}_{0.8}\text{Mo}_{0.1}\text{Al}_{0.1}\text{Ni}_{8.0}\text{Me}_{1.0}\text{Al}_{1.0}$ , and  $\text{Co}_{0.64}\text{Ni}_{0.24}\text{Al}_{0.12}\text{Ce}_{6.4}\text{Ni}_{2.4}\text{Al}_{1.2}$ . In certain embodiments, the nanoparticles are nanotubes having a length less than about 200  $\mu\text{m}$  and a width less than about 100 nm. In certain embodiments, the nanoparticles are nanotubes having a diameter of about 10 nm to about 100 nm.

V. Please replace the paragraphs [0021] to [0024] with the following amended paragraphs:

**[0021]** This invention also provides methods of preparing a fuel cell element. The method typically involves providing a plurality of fibers and/or a porous electrode material; depositing a nanoparticle catalyst on the plurality of fibers and/or porous electrode material; forming nanoparticles on the plurality of fibers and/or porous electrode material using the nanoparticles catalyst; and forming a catalytically active layer comprising a substantially continuous thin film on the nanoparticles thereby forming a fuel cell element comprising a plurality of fibers bearing nanoparticles partially or fully coated with a catalytically active thin film. In certain embodiments, the plurality of fibers comprises a plurality of carbon fibers (*e.g.*, a carbon fiber paper or other porous carbon electrode). In certain embodiments, the nanoparticle catalyst is a carbon nanotube catalyst, *e.g.* as described herein, and/or the nanoparticles are carbon nanotubes, *e.g.*, as described herein and/or the substantially continuous thin film is a catalytically active thin film, *e.g.*, as described herein. In certain embodiments, the nanoparticles are formed by chemical vapor deposition (CVD). In certain embodiments, the depositing a nanoparticle catalyst comprises depositing the catalyst on fibers by chemical vapor deposition (CVD). In certain preferred embodiments, the nanotube growth catalyst is a catalyst selected from the group consisting of  $\text{Co}_{1-x}\text{Mo}_x$  where  $0 \leq x \leq 0.3$ ,  $\text{Co}_{1-x-y}\text{Ni}_x\text{Mo}_y$  where  $0.1 \leq x \leq 0.7$  and  $0 \leq y \leq 0.3$ ,  $\text{Co}_{1-x-y-z}\text{Ni}_x\text{V}_y\text{Cr}_z$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ ,  $0 \leq z \leq 0.2$ ,  $\text{Ni}_{1-x-y}\text{Mo}_x\text{Al}_y$  where  $0 \leq x \leq 0.2$  and  $0 \leq y \leq 0.2$ , and  $\text{Co}_{1-x-y}\text{Ni}_x\text{Al}_y$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ . Certain suitable catalysts include, but are not limited to  $\text{Co}_{0.88}\text{Mo}_{0.12}\text{Ce}_{0.8}\text{Me}_{1.2}$ ,  $\text{Co}_{0.22}\text{Ni}_{0.56}\text{Mo}_{0.22}\text{Ce}_{2.2}\text{Ni}_{5.6}\text{Me}_{2.2}$ ,  $\text{Co}_{0.57}\text{Ni}_{0.21}\text{V}_{0.11}\text{Cr}_{0.11}\text{Ce}_{5.7}\text{Ni}_{2.1}\text{V}_{1.1}\text{Cr}_{1.1}$ ,  $\text{Ni}_{0.8}\text{Mo}_{0.1}\text{Al}_{0.1}\text{Ni}_{8.0}\text{Me}_{1.0}\text{Al}_{1.0}$ , and  $\text{Co}_{0.64}\text{Ni}_{0.24}\text{Al}_{0.12}\text{Ce}_{6.4}\text{Ni}_{2.4}\text{Al}_{1.2}$ . In certain embodiments, providing a plurality of fibers and/or a porous electrode material comprises providing a carbon fiber

paper; depositing a nanoparticle catalyst comprises depositing said catalyst by chemical vapor deposition; forming nanoparticles comprises forming carbon nanotubes; and forming a catalytically active layer comprising depositing a substantially continuous thin film comprising platinum or a platinum alloy.

**[0022]** This invention also provides a method of making a carbon nanotube for use in a fuel cell. The method typically involves providing a nanotube growth catalyst selected from the group consisting of  $\text{Co}_{1-x}\text{Mo}_x$  where  $0 \leq x \leq 0.3$ ,  $\text{Co}_{1-x-y}\text{Ni}_x\text{Mo}_y$  where  $0.1 \leq x \leq 0.7$  and  $0 \leq y \leq 0.3$ ,  $\text{Co}_{1-x-y-z}\text{Ni}_x\text{V}_y\text{Cr}_z$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ ,  $0 \leq z \leq 0.2$ ,  $\text{Ni}_{1-x-y}\text{Mo}_x\text{Al}_y$  where  $0 \leq x \leq 0.2$  and  $0 \leq y \leq 0.2$ , and  $\text{Co}_{1-x-y}\text{Ni}_x\text{Al}_y$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ ; and forming a carbon nanotube on said catalyst (*e.g.* by CVD). In certain embodiments, the catalyst is a catalyst selected from the group consisting of  $\text{Co}_{0.88}\text{Mo}_{0.12}$ ,  $\text{Co}_{8.8}\text{Mo}_{1.2}$ ,  $\text{Co}_{0.22}\text{Ni}_{0.56}\text{Mo}_{0.22}$ ,  $\text{Co}_{2.2}\text{Ni}_{5.6}\text{Mo}_{2.2}$ ,  $\text{Co}_{0.57}\text{Ni}_{0.21}\text{V}_{0.11}\text{Cr}_{0.11}$ ,  $\text{Co}_{5.7}\text{Ni}_{2.1}\text{V}_{1.1}\text{Cr}_{1.1}$ ,  $\text{Ni}_{0.8}\text{Mo}_{0.1}\text{Al}_{0.1}$ ,  $\text{Ni}_{8.0}\text{Mo}_{1.0}\text{Al}_{1.0}$ , and  $\text{Co}_{0.64}\text{Ni}_{0.24}\text{Al}_{0.12}$ ,  $\text{Co}_{6.4}\text{Ni}_{2.4}\text{Al}_{1.2}$ .

**[0023]** Also provided is a carbon nanotube comprising a nanotube growth catalyst selected from the group consisting of  $\text{Co}_{1-x}\text{Mo}_x$  where  $0 \leq x \leq 0.3$ ,  $\text{Co}_{1-x-y}\text{Ni}_x\text{Mo}_y$  where  $0.1 \leq x \leq 0.7$  and  $0 \leq y \leq 0.3$ ,  $\text{Co}_{1-x-y-z}\text{Ni}_x\text{V}_y\text{Cr}_z$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ ,  $0 \leq z \leq 0.2$ ,  $\text{Ni}_{1-x-y}\text{Mo}_x\text{Al}_y$  where  $0 \leq x \leq 0.2$  and  $0 \leq y \leq 0.2$ , and  $\text{Co}_{1-x-y}\text{Ni}_x\text{Al}_y$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ . In certain embodiments, the catalyst is a catalyst selected from the group consisting of  $\text{Co}_{0.88}\text{Mo}_{0.12}$ ,  $\text{Co}_{8.8}\text{Mo}_{1.2}$ ,  $\text{Co}_{0.22}\text{Ni}_{0.56}\text{Mo}_{0.22}$ ,  $\text{Co}_{2.2}\text{Ni}_{5.6}\text{Mo}_{2.2}$ ,  $\text{Co}_{0.57}\text{Ni}_{0.21}\text{V}_{0.11}\text{Cr}_{0.11}$ ,  $\text{Co}_{5.7}\text{Ni}_{2.1}\text{V}_{1.1}\text{Cr}_{1.1}$ ,  $\text{Ni}_{0.8}\text{Mo}_{0.1}\text{Al}_{0.1}$ ,  $\text{Ni}_{8.0}\text{Mo}_{1.0}\text{Al}_{1.0}$ , and  $\text{Co}_{0.64}\text{Ni}_{0.24}\text{Al}_{0.12}$ ,  $\text{Co}_{6.4}\text{Ni}_{2.4}\text{Al}_{1.2}$ .

**[0024]** Carbon nanotube growth catalysts (*e.g.*, for growing carbon nanotubes for use in a fuel cell) are also provided. Preferred catalysts include catalysts selected from the group consisting of  $\text{Co}_{1-x}\text{Mo}_x$  where  $0 \leq x \leq 0.3$ ,  $\text{Co}_{1-x-y}\text{Ni}_x\text{Mo}_y$  where  $0.1 \leq x \leq 0.7$  and  $0 \leq y \leq 0.3$ ,  $\text{Co}_{1-x-y-z}\text{Ni}_x\text{V}_y\text{Cr}_z$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ ,  $0 \leq z \leq 0.2$ ,  $\text{Ni}_{1-x-y}\text{Mo}_x\text{Al}_y$  where  $0 \leq x \leq 0.2$  and  $0 \leq y \leq 0.2$ , and  $\text{Co}_{1-x-y}\text{Ni}_x\text{Al}_y$  where  $0 \leq x \leq 0.7$  and  $0 \leq y \leq 0.2$ . In certain embodiments, the catalyst is selected from the group consisting of  $\text{Co}_{0.88}\text{Mo}_{0.12}$ ,  $\text{Co}_{8.8}\text{Mo}_{1.2}$ ,  $\text{Co}_{0.22}\text{Ni}_{0.56}\text{Mo}_{0.22}$ ,  $\text{Co}_{2.2}\text{Ni}_{5.6}\text{Mo}_{2.2}$ ,  $\text{Co}_{0.57}\text{Ni}_{0.21}\text{V}_{0.11}\text{Cr}_{0.11}$ ,  $\text{Co}_{5.7}\text{Ni}_{2.1}\text{V}_{1.1}\text{Cr}_{1.1}$ ,  $\text{Ni}_{0.8}\text{Mo}_{0.1}\text{Al}_{0.1}$ ,  $\text{Ni}_{8.0}\text{Mo}_{1.0}\text{Al}_{1.0}$ , and  $\text{Co}_{0.64}\text{Ni}_{0.24}\text{Al}_{0.12}$ ,  $\text{Co}_{6.4}\text{Ni}_{2.4}\text{Al}_{1.2}$ .

VI. Please replace the paragraph [0073] with the following amended paragraph:

[0073] In certain particularly preferred embodiments the catalysts for growing the nanoparticles include, one or more of the following:  $\text{Co}_{0.88}\text{Mo}_{0.12}\text{Ce}_{8.8}\text{Me}_{1.2}$ ,  $\text{Co}_{0.22}\text{Ni}_{0.56}\text{Mo}_{0.22}\text{Ce}_{2.2}\text{Ni}_{5.6}\text{V}_{2.2}\text{Me}_{2.2}$ ,  $\text{Co}_{0.57}\text{Ni}_{0.21}\text{V}_{0.11}\text{Cr}_{0.11}\text{Ce}_{5.7}\text{Ni}_{2.4}\text{V}_{1.1}\text{Cr}_{1.1}$ ,  $\text{Ni}_{0.8}\text{Mo}_{0.1}\text{Al}_{0.1}\text{Ni}_{8.0}\text{Me}_{1.0}\text{Al}_{1.0}$ , and  $\text{Co}_{0.64}\text{Ni}_{0.24}\text{Al}_{0.12}\text{Ce}_{6.4}\text{Ni}_{2.4}\text{Al}_{1.2}$ .